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GROUNDWATER IN WADI ESEL BASIN EASTERN DESERT, EGYPT

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ABSTRACT

During the last seven years, the Desert Research Center carried out intensive research work in the Eastern Desert through Mineral, Petroleum and Groundwater Assessment Program (MPGAP). This work proved that most of the drainage basins in this desert have high groundwater potentialities due to the occurrence of several water bearing formations (aquifers) of different rock types.

Wadi Esel basin, to the south of El Quseir, is one of such basins where a number of productive aquifers is detected, e.g., Quaternary alluvium, Middle Miocene sandstone and Precambrian Hammamat rocks.

This study presents a hydrogeological and hydrochemical assessment of such aquifers for evaluation of their groundwater for different purposes. The characters and the relationships between aquifers were discussed through the study of the effect of some structural elements on groundwater. The water quality indicates that the groundwater varies generally between fresh and slightly saline in the different aquifers. Only the Hammamat groundwater can be safely used in drinking and laundry, while both the Middle Miocene sandstone and the Hammamat water are suitable for irrigation.

INTRODUCTION

El-Quseir area is characterized by considerable tourist activities and the existence of the most important phosphate mines in Egypt. The present water supplies in this area are generally insufficient (about 700 m3/day of Nile water) to meet the expected increase in water demands. For this reason, efforts are now

directed to groundwater exploration and evaluation for different activities.

Wadi Esel basin is selected for detailed hydrogeological studies to determine its groundwater potentiality. Two wells were recently drilled by the Desert Research Center in this basin and inventory of the actually existing wells was made. Periodical hydrogeogical measurements and groundwater sampling (December, 1983-March, 1990) were also carried out.

Wadi Esel basin lies at 22 km south El Quseir and is bounded by longitudes 34° 00′ and 34° 24′ E and latitudes 25° 36′ and 25° 59′ N (Figs. 1 and 2).

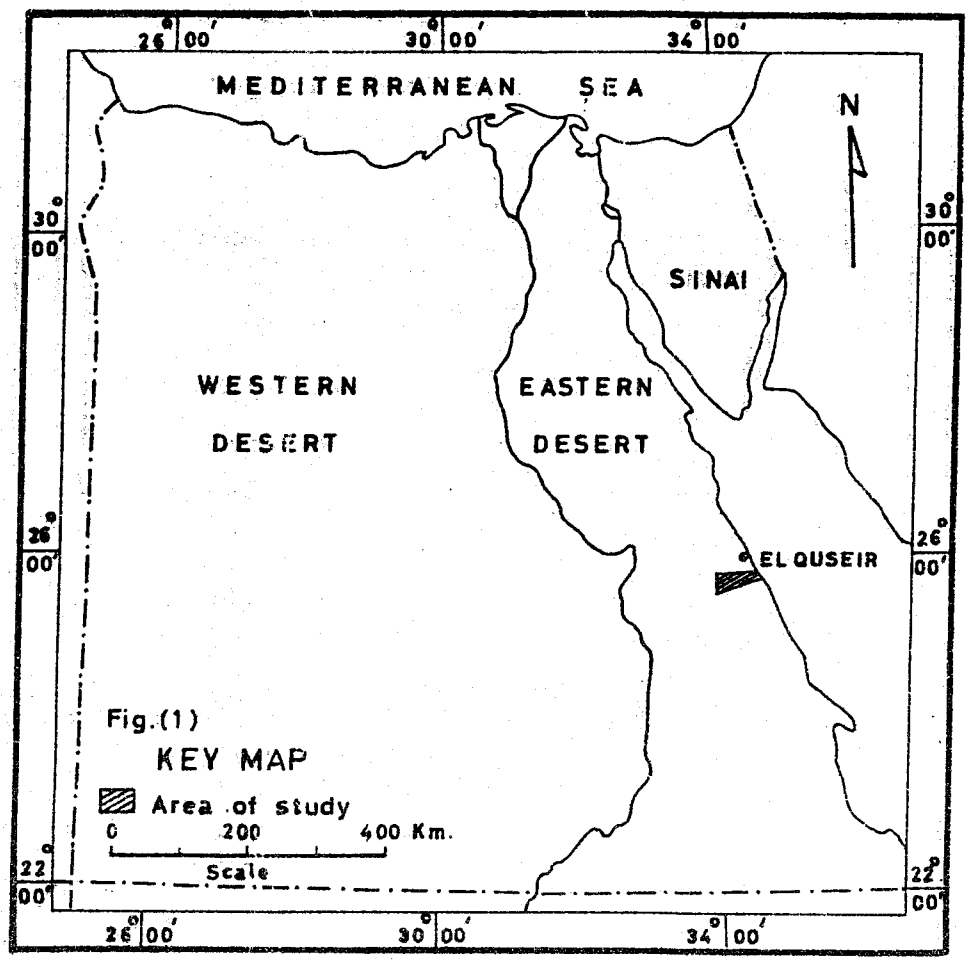
PHYSICAL SETTING

The Eastern Desert is located within the extremely arid province of Egypt. Its climate is characterized by high temperature, high evaporation and high variability of precipitation.

The meteorological stations in the Eastern Desert are few compared with the total area. However, information about the climatic elements in El Quseir is recorded. Such information indicate that the total annual precipitation is 3.2 mm, the maximum air temperature is 33.4°C in August, the maximum evaporation is 16 mm/day in June and the maximum humidity is 54% in October.

The local precipitation and temporary floods represent the main source of groundwater in the Eastern Desert as well as in the study basin. In the last 30 years, floods have been recorded in 1958, 1969 and 1980. Moreover, in October 1984 several wadis in south El Quseir area were flooded causing replenishment of groundwater.

The study basin has an area of about 716.8 km2 and drains the Red Sea Mountain Shelf which is formed of igneous and metamorphic rocks. The main


26° 00'
30° 00'
34° 00'
MEDITERRANEAN SEA
N
30° 00'
SINAI
WESTERN DESERT
EASTERN DESERT
26° 00'
EL QUSEIR
22° 00'
Fig.(1)
KEY MAP
Area of study
0 200 400 Km.
Scale

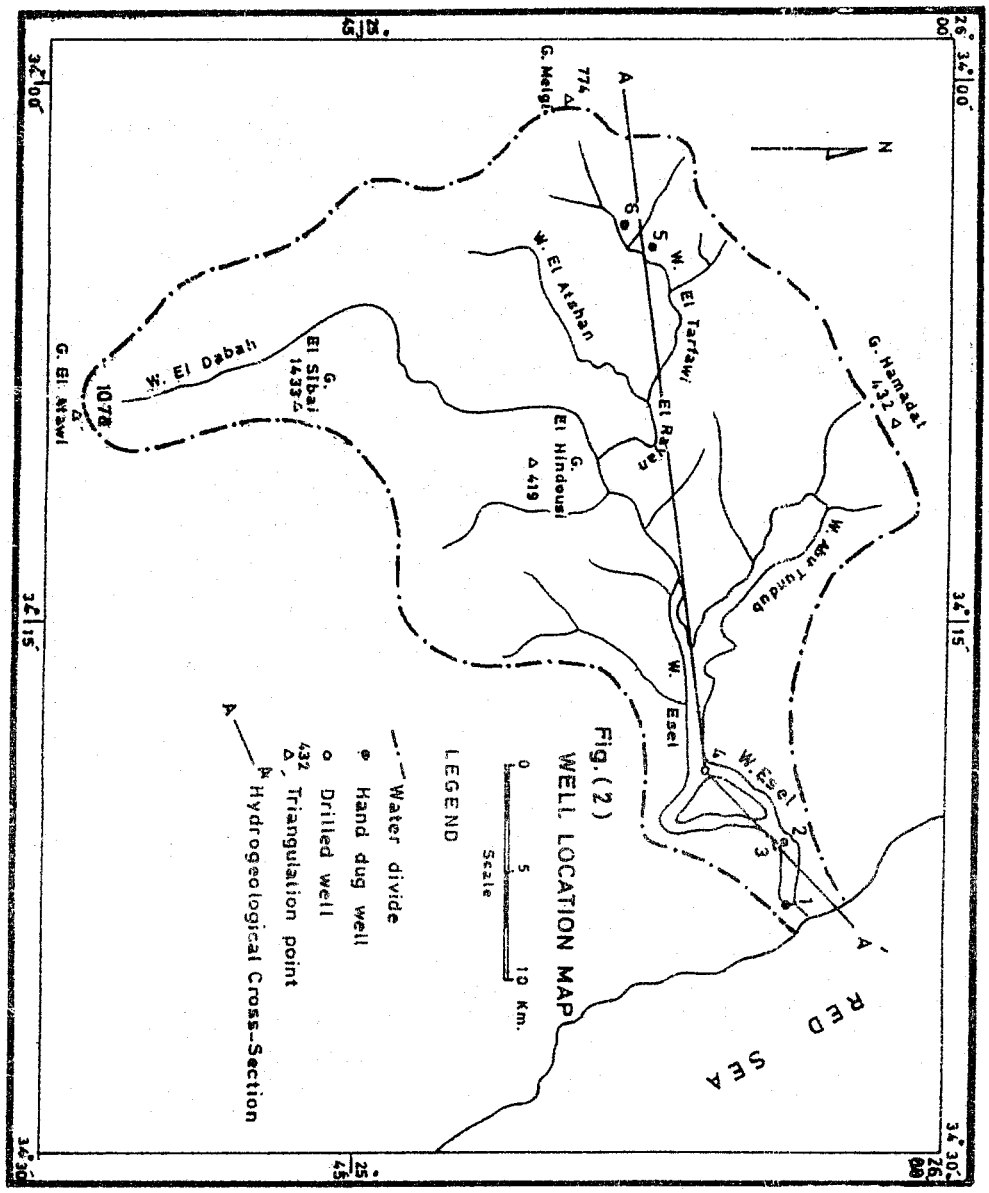


Fig. (2)
WELL LOCATION MAP
LEGEND
Water divide
Hand dug well
Drilled well
Triangulation point
Hydrogeological Cross-Section
Scale
0
5
10 Km.
RED SEA
W. Essel
W. El Tarfawi
W. El Atshan
W. El Dabah
W. Abu Tundub
G. Hamadat
G. Meiga
G. El Sibai
G. El Hindousi
G. El Atawi
El Rayes

channel of wadi Esel runs nearly in an east-west direction. It is characterized by steep slopes with an extended flood plain and alluvial terraces.

The headwaters of wadi Esel originates in Gebels Hamadat (+ 432 m), Melgi (+ 774 m), El Atawi (+ 1078 m) and Gebel El Sibai (+ 1433 m). These headwaters scour numerous fingers tip channels, e.g., wadis El–Tarfawi, El Atshan, El–Dabah and wadi Abu Tundab (Fig. 2). The majority of these wadis are narrow (± 200 m width), meandered, gently slopping and bounded with steep almost vertical cliffs. These wadis join wadi Esel main trunk before it flows to the Red sea.

The drainage pattern of Esel basin was quantitatively analysed by El–Fakharany (1989). This analysis indicates that the basin is elongated in shape which allows runoff water to take place for longer period of time giving more chance to feed the shallow water bearing formations. Thus, he recommended for barriers to be constructed to increase recharge to the aquifers.

Stratigraphically, the exposed rocks in wadi Esel basin belong to Precambrian, Upper Cretaceous, Lower Eocene, Middle Miocene and Quaternary. The catchment area of this wadi is mainly composed of Hammamat rocks, besides metavolcanic and granitic rocks (Fig. 3). In the subsurface, the basement rocks are encountered at 76 m depth (well No. 3).

According to the available geological information (El Akkad and Dardir, 1966, Issawi *et al.*, 1971 and Sabit *et al.*, 1976), the sedimentary succession overlying the basement rocks is discriminated, into the following, from older to younger :

- **The Upper Cretaceous rocks;** differentiated into Lower Maestrichtian unit and Upper Maestrichtian - Danian one. The Lower Maestrichtian unit (Duwi Formation) consists of lower shaley part and upper Oyster biohermal part with three

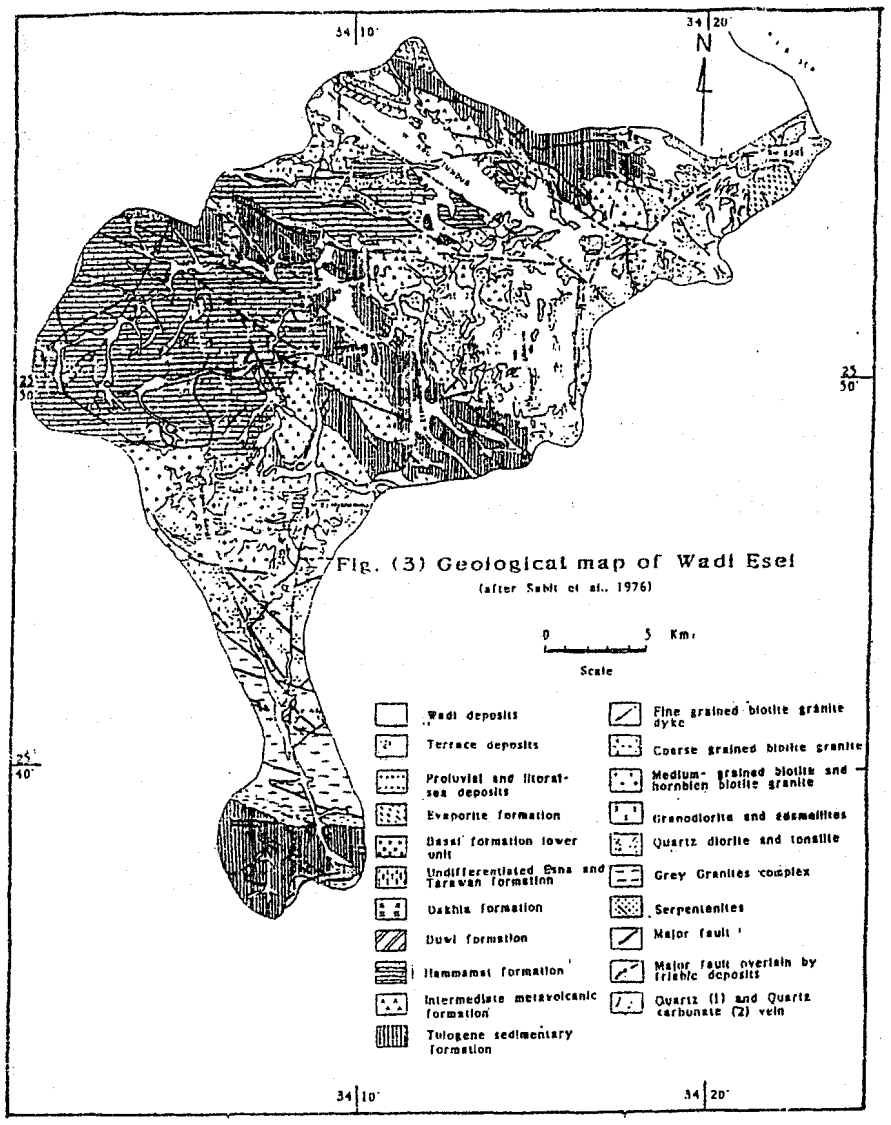


Fig. (3) Geological map of Wadi Esel
(after Sabit et al., 1976)

horizontal phosphate beds. On the other hand, the Upper Maestrichtian - Danian rock unit is represented by Dakhla shale which composed of upper shale (Anz Member) and lower marl beds (Beida Member). The whole section does not bear water.

- **The Lower Eocene rocks (Thebes Formation);** built up of limestone with chert bands (not detected as water bearing formation).

- **The Middle Miocene rocks;** differentiated into a lower permeable water bearing unit (Gebel El-Rusas Formation) consists of sandstone, shale and conglomerate and an upper imprevious confining one (Abu Dabbab Formation) formed of gypsum and shale.

- **The Quaternary deposits;** composed of water bearing sand, conglomerate and silt.

Structurally, wadi Esel is commonly dissected by NW-SE step faults parallel to the Red Sea. The northeast faults are limited. Dykes and fractures are local strructures predominated in the basement rocks. The latters have a direct effect on groundwater recharge.

GROUNDWATER OCCURRENCES

The groundwater of wadi Esel basin is encountered in the following water bearing formations (Fig. 4) :

- The Quaternary alluvial aquifer.
- The Middle Miocene sandstone aquifer.
- The Precambrian fractured Hammamat aquifer.

The physical properties, distribution and the hydrogeological conditions of these aquifers will be discussed as follows :

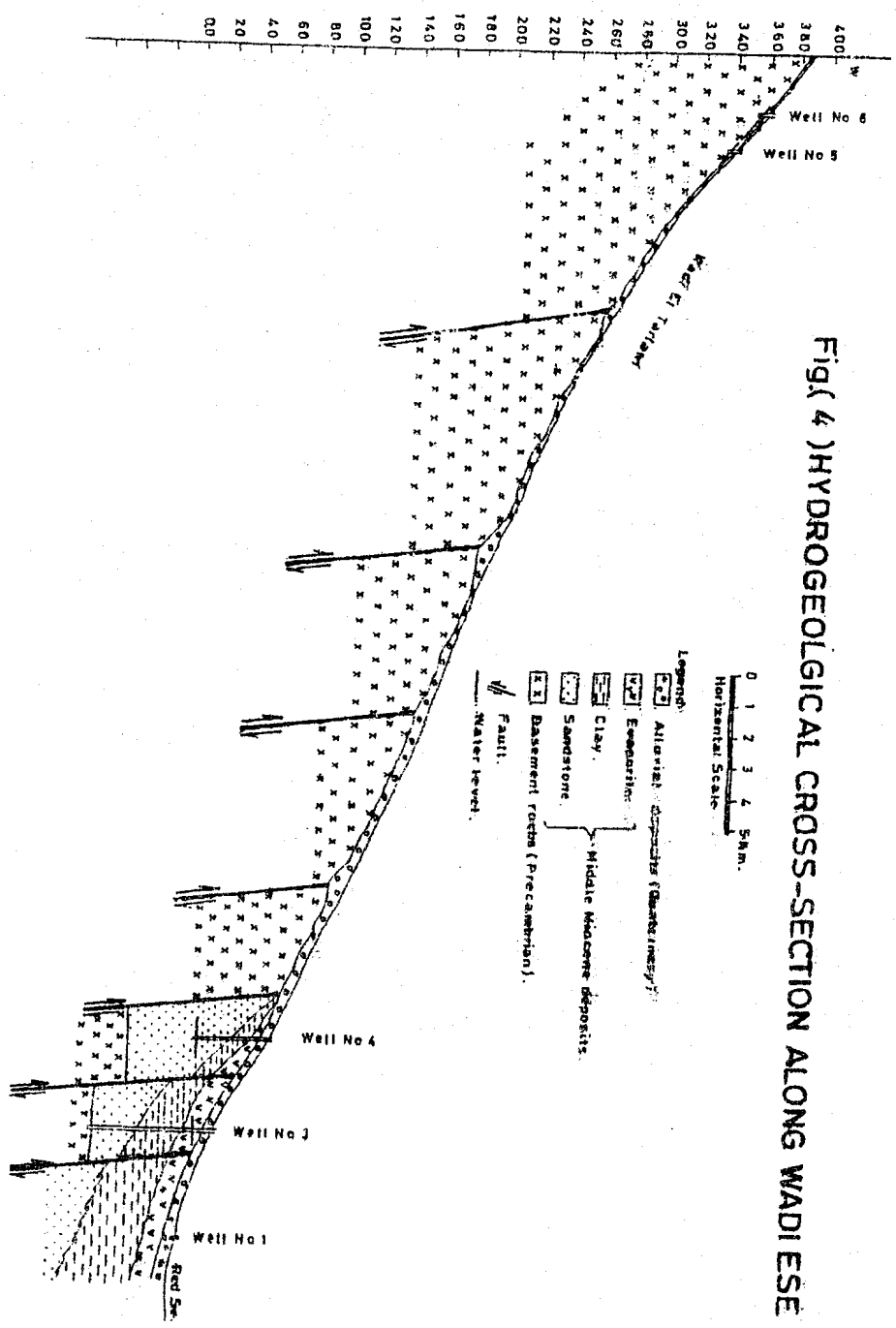


Fig.(4)HYDROGEOLGICAL CROSS-SECTION ALONG WADI ESE

1- The Quaternary alluvial aquifer :

The Quaternary alluvial deposits cover the course of wdi Esel and its tributaries forming wadi terraces. They are dominated by sand pebbles interbeds of more than 5 m thick.

The alluvial deposits are detected as water bearing formation in the deltas of wadis along the Red Sea Coast south of El Quseir, where the groundwater exists in the form of thin sheets at depths varying from 2 m to about 12 m from ground surface.

In the delta of wadi Esel, the floor is characterized by gentle slope which give a chance for the local rainfall and surface runoff to infiltrate and feed this aquifer. A hand dug well, put down by the inhabitants, was tapping the alluvial aquifer before it was silted up (well No. 1, Fig 2).

The alluvial aquifer rests directly either on the fractured basement rocks at the upstream portion or on the Middle Miocene evaporites and shale at the downstream portion (Fig. 4). The latters act as impervious layers preventing the downward movement of groundwater to the underlying water bearing formation (the Middle Miocene sandstone). So, the water seeps laterally towards the Red Sea.

The quality of water in a well tapping the alluvial aquifer and located some 10 km north wadi Esel is brackish to slightly saline. The total salinity of water varies generally between 3000 mg/l and 3600 mg/l.

2- The Middle Miocene sandstone aquifer :

The Middle Miocene sediments are widely distributed in the coastal plain south of El Quseir forming a portion of the low hilly region. They are composed of a basal sandstone, shale and limestone unit (Gebel El Rusas Formation) and an

upper one composed of gypsum, shale and marl (Abu Dabbab Formation). These sediments, having an exposed thickness of about 243.5m (Issawi *et al.*, 1971), are unconformably overlying the basement rocks.

The basal sandstone is detected as water bearing formation at the lower reaches of wadi Esel, where a hand dug well (well No 2) and two drilled wells (wells No. 3 and 4) are put down at some 4 to 7 km inland from the Red Sea. Such wells tap this aquifer at depths varying between 11.7 m and 12.0 m from the ground surface.

Dykes and faults have a certain bearing upon the Middle Miocene sandstone aquifer of wadi Esel. In the down stream portion, some 4 km from the Red Sea coast, there is a granitic dyke crossing the main channel and runs in a NW-SE direction. This dyke is affected by a major fault runs in a NE-SW direction and originates natural passages which allow the groundwater to pass through. In addition, local precipitation on the sandstone exposures infiltrates downward and feeds this sandstone in the subsurface (well No. 2). However, the presence of the impervious evaporites and shale of Abu Dabbab Formation overlying the sandstone aquifer in wells No. 3 and 4 prevents any feeding from surface (Fig. 4). Therefore, the existence of this aquifer in juxtaposition with the basement rocks, due to faulting, allows certainly the possible feeding from the basement. This concept is supported by the presence of longitudinal faults parallel to the course of wadis El Tarfawi and Esel (Fig. 3). These faults assist in forming passages for groundwater between the upper reaches and the lower reaches of wadi Esel.

Dealing with the hydraulic parameters of the Middle Miocene sandstone aquifer in wadi Esel basin, a pumping test was carried out in well No. 3 for 9 hours with a discharge rate of 19.4 m3/h. The drawdown of the groundwater level during pumping was observed in the productive well and in a piezometer which is lined at a

distance of 6.3 m. The maximum drawdown in the pumped well and the piezometer was 3.2 m and 1.45 m. respectively. The data of this pumping test were analyzed by Sewidan (1990). The results obtained are :

Transmissivity	(T)	= 69 m2/day
Storativity	(S)	= 1.2 x 10-3
Hydraulis conductivity	(K)	= 4.31 m/day

3 - The precambrian fractured Hammamat aquifer :

The fractured Hammamat rocks constitute the majority of the catchment area in wadi Esel. They are composed of conglomerate, gritstone, sandstone, siltstone and claystone. The surface of these rocks is dissected by a network of fractures with wide width reaching more than 10 cm. The joint density is high (30 joint/m2). These joints and fractures act as good conduits for water.

The groundwater of the fractured Hammamat aquifer is detected in two hand dug wells (wells No. 5 and 6) put down in wadi El Tarfawi (secondary channel of wadi Esel). The groundwater exists at depth ranging between 2.5 m and about 6.0 m from ground surface. This aquifer is recharged directly from local precipitation.

GROUNDWATER QUALITY

The exploitable aquifers in wadi Esel basin are mainly the Middle Miocene sandstone and the fractured Hammamat rocks. Considerable amounts of groundwater are obtained from both aquifers through few number of hand dug and drilled wells (total 4). Both groundwaters are of variable quality due to location, lithology and recharge.

The groundwater quality of the Middle Miocene sandstone and the fractured Hammamat rocks will be discussed through the chemical analysis of 16 water

samples collected from wells No. 2, 3, 5 and 6 in number of cycles between the time interval extended from December, 1983 to March, 1990. The results of chemical analysis are shown in table (1).

Referring to table (2), the chemical characteristics of the concerned aquifers are described as follows :

1- Groundwater of the Middle Miocene sandstone aquifer :

a - The groundwater of the Middle Miocene sandstone varies from brackish to slightly saline. Its average salinity ranges from 2700 mg/l (well No. 3) to 3700 mg/l (well No. 2). This relatively high salinity is due to leaching processes, water stagnancy, low rate of recharge and alteration due to hydrothermal activity.

b - According to ions concentrations, the sequence of abundance of both anions and cations follows the orders; $Cl^- > SO_4^{--} > HCO_3^-$ and $Na^+ > Mg$ (Ca^{++}) > Ca^{++} (Mg^{++}). Therefore, the water chemical type is chloride - sodium. The two main elements, chloride and sodium, have close values in average. Mostly, magnesium exceeds calcium, while chloride is 2-3 times the sulphate.

c - Based on ions combination, the marine salts NaCl, MgCl2, MgSO4, CaSO4 and Ca(HCO3)2 are mainly detected in the groundwater. These salts are resulted from leaching of evaporites and shale (Abu Dabbab Formation), through direct contact. Moreover, this groundwater has values for the ratios rNa/rCl, rSO4 / rCl and rCa/rMg comparable with those of sea water. This also indicates the impact of marine sediments on water qulity (Table 2).

d - The classification of water quality on the semi-logarithmic graph of schoeller (1962) is shown in figure (5). This graph indicates the relationships between the different constituents as expressed by the slope of the lines connecting these constituents (in milliequivalent/litre). So, the two lines representing the

Table (1) : Results of chemical analyses of groundwater in wadi Esel (concentrations in mg/l).

Well No.	Aquifer	Date of sampling	pH	EC m.mhos/cm.	TDS (mg/l)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl
2	Middle	Dec. 83	8.3	9098	5138	190.9	232	1400	54	29.38	375	500	2544
2	Miocene	Oct. 84		4512	3018	179.0	96.72	750	27.5	23.23	414.45	750	979
2	Sandstone	Dec. 84	7.9	6992	3607	281.4	97.68	910	32.5	14.11	459.0	520	1522
2		Dec. 89	7.6	4400	2880	129.29	127.7	725	25.0	-	382.3	510	1174
3		April 88	7.5		2808	150.4	183.2	600	12.5	8.34	127.18	658	1136
3		Dec. 89	7.23	4100	2543	153.53	130.09	615	16.5	-	70.15	370	1223
3		March 90	7.5		2888	160.0	114.0	730	13.8	-	64.0	400	1400
5	Hammamat	Feb. 84	7.6	2430	1414	54.70	18.13	435	7.0	17.48	242.8	450	311
5	Rocks	March 84	7.8	2449	1357	71.64	21.76	375	9.5	-	331.35	380	332
5		Oct.84		2041	1227	67.66	12.09	360	10.0	17.42	312.3	300	304
5		Dec.84	7.6	4968	2683	112.56	85.03	740	21.5	-	484.2	600	885
5		Dec. 89	7.51	2800	1766	96.96	34.36	520	7.0	-	378.8	380	538
6		Feb. 84	7.7	1580	900	45.36	27.56	250	4.0	8.74	204.35	245	215
6		March 84	8.0	1659	868	55.72	19.34	240	5.0	17.46	213.0	200	225
6		Oct. 84		1853	1000	63.68	31.43	260	4.5	19.36	237.7	190	310
6		Dec. 84	8.4	2034	1137	72.36	17.09	325	6.5	21.17	297.2	260	287
Rain water		Oct.84	7.0	-	80	10.8	3.01	15	2.0	-	49.0	10	15
Red sea water		Oct. 84	7.74	-	44000	577	644	14000	250	35	110	3200	24235

Table (2) : Hydrochemical parameters wadi Esel groundwater

Well No.	Location	Aquifer	Depth to water (m)	Average TDS (mg/l)	Average rNa/rCl	Average rCa/rMg	Average rSO_4/rCl	Ion dominance	Water type	Dominant salt combinations
2	Downstream	Middle Miocene sandstone	12	3660	0.975 (0.85)*	0.995 (0.20)*	0.32 (0.10)*	$Cl > SO_4 > HCO_3$ Na > Mg (Ca) > Ca (Mg)	Chloride-sodium	NaCl, $MgCl_2$, $MgSO_4$, $CaSo_4$, $Ca(HCO_3)_2$
3	Downstream	Middle Miocene sandstone	11.7	2744	0.79	0.47	0.50	$Cl > SO_4 > HCO_3$ Na > Mg > Ca	chloride sodium	NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$ $Ca(HCO_3)_2$
5	W. El-Tarfawi	Precambrian Hammamat	2.45	1690	1.7 (1.54)**	1.99 (2.16)**	0.73 (0.50)**	$Cl > SO_4 > HCO_3$ Na > Ca > Mg	Chloride sodium	NaCl, Na_2SO_4, $MgSO_4$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$
6	W.El-Tarfavi	Precambrian Hammamat	5.96	976	1.61	1.63	0.65	$Cl > HCO3 (SO4) > SO_4 (HCO_3)$/Na >	Chloride sodium	NaCl, Na_2SO_4, $MgSO_4$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$

(0.85)* average value in sea water
(1.54)** average value in fresh meteoric water (precipitation)

Middle Miocene sandstone groundwater (wells No. 2 and 3) show slight variation in the concentration of the corresponding constituents. This is attributed to the varying effect of the factors controlling the water quality in the two wells. However, the graph shows that the groundwater is characterized by the pattern; $Ca^{++} < Mg^{++} < Na^{+} < Cl^{-} > SO_4^{--} > HCO_3^{-}$.

e - With regard to the suitability of water quality for domestic and irrigation purposes, it can be noticed that the Middle Miocene water is unsuitable for drinking and laundry purposes as the determined values of salinity, chloride, sulphate, magnesium and calcium carbonate hardness exceed the permissible limits of domestic use as given by the U.S. Public Health Service (1962) : TDS (1000mg/1), Cl- (250 mg/1), SO_4^{--} (250 mg/1), Mg^{++} (125 mg/1) and $CaCO_3$ hardness (60-120 mg/1). For irrigation purposes, on the other hand, the U.S. Laboratory Staff (1954) classified the irrigation water on basis of the sodium adsorption ratio (SAR)* as follows :

Class	SAR	Quality	Usage
I	0 - 10	Low sodium	can be used in all soils
II	10 - 18	Medium sodium	preferable used in coarse texture soils with good permeability
III	18 - 26	High sodium	cam produce harmful effect; good soil management essential

* SAR = Na+ / (Ca++ + Mg++) / 2

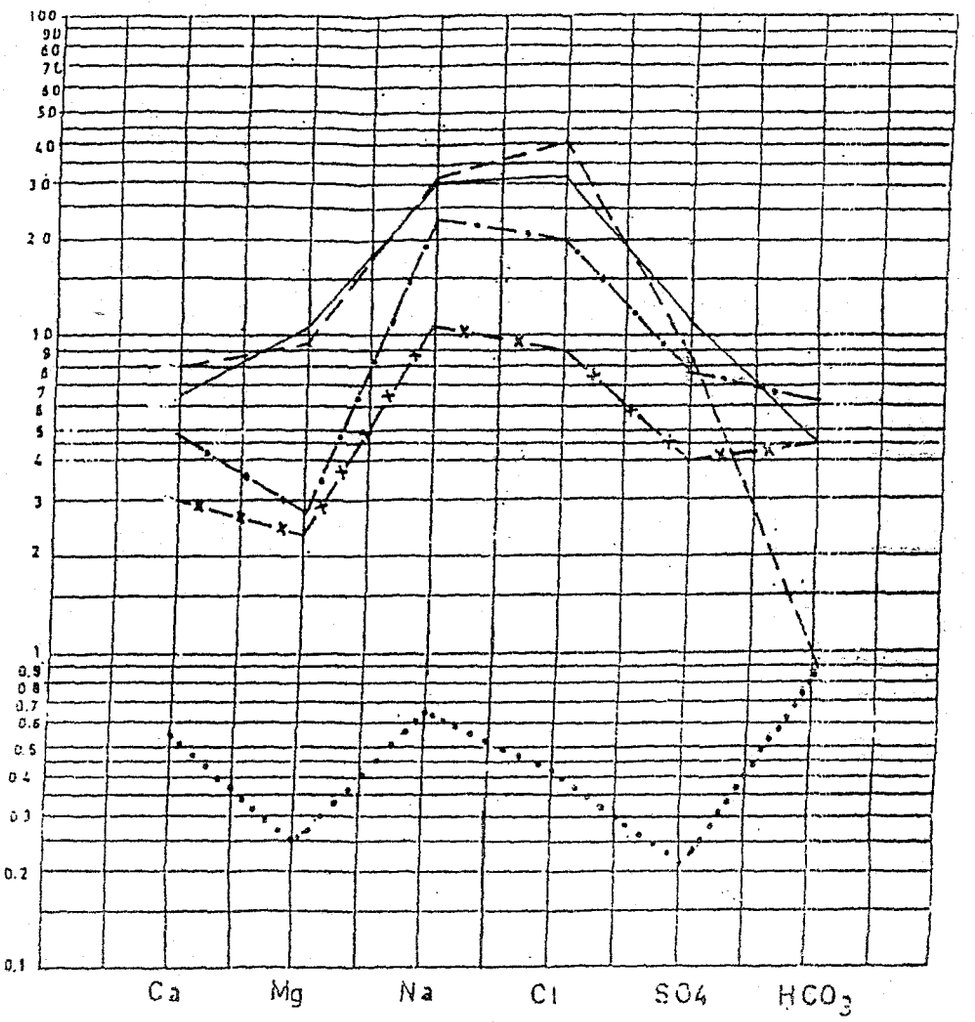


Fig. (5) SEMI- LOGARITHMIC REPRESENTATION

Legend

Well No. 2 | Middle Miocene sandstone
Well No. 3 | Middle Miocene sandstone
Rainwater
Well No. 5 | Hammamat rocks
Well No. 6 | Hammamat rocks

The sodium adsorption ratio for the concerned aquifer ranges between 7.7 and 11.9. Accordingly, the Middle Miocene groundwater can be used for irrigation of all soils and coarse texture soils with good permeability.

2- Groundwater of the fractured Hammamat aquifer :

a - The groudwater of the fractured Hammamat rocks varies from fresh to slightly brackish (Table 2). Its average total salinity ranges from 980 mg/l (well No. 6) to 1700 mg/l (well No. 5). These relatively low salinity values could be attributed to the following :

- The composition and coarse texture of the Hammamat rocks (breccia and conglomerate).

- The dense and wide fracture system which accelerates the infltration rate and minimizes the role of leaching processes.

- The low rate of evaporation due to shading of high escarpments.

- The closeness to the replinishment area.

b - According to their dominance, the ions are arranged in descending order as follows :

$Cl^- > SO_4^{--} (HCO_3)- > HCO^-_3 (SO_4)$ -- and $Na^+ > Ca^{++} > Mg^{++}$. The concentration of sodium is nearly double that of chloride while calcium is prevailed over magnesium by the same ratio. Therefore, the values of rNa/rCl and rCa/rMg are always more than unity and can be correlated with those of fresh meteoric water (Table 2). This indicates the meteoric origin for the groundwater (precipitation).

c - The concentration of ions reveals the formation of two group of salts in

the groundwater ;

NaCl, Na_2SO_4, $MgSO_4$, Mg $(HCO_3)_2$, $Ca(HCO_3)_2$ and NaCl, Na_2SO_4, $NaHCO_3$, Mg $(HCO_3)_2$, Ca $(HCO_3)_2$. These salt groups characterize fresh meteoric water and resistant water bearing rocks (Hem. 1959).

d - From the semi-lorgarithmic graph (Fig. 5), it is evident that the lines representing the Hammamat groundwater (wells No. 5 and 6) and rainwater exhibit nearly parallel relations. This parallelism means that the groundwater tapped from the Hammamat aquifer is developed from rainwater and hence, both water types are characterized by the pattern $Ca^{++} > Mg^{++} < Na^{+} > Cl^{-} > SO_4^{--} < HCO_3^{-}$. Moreover, the graph indicates that there is a chemical relation between the Hammamat and the Middle Miocene aquifer. This relation is defined from the lines of wells No. 2, 5 and 6 which show nearly identical ion relationships with the exception of the Ca^{++} - Mg^{++} and SO_4^{--} - HCO_3^{-} ratios which are different, due to the ion exchange and leaching processes.

e - On basis of the U.S. Public Health service standards (1962) mentioned before, it can be concluded that the water of well No. 6 is suitable for domestic purpose, while that of well No. 5 is unsuitable for the same purpose but can be used under special circmstances. However, both wells can be used for irrigation of all soils and also coarse textured and highly permeable ones (U.S. Laboratory Staff, 1954). Their SAR values range from 6.7 to 12.9.

RECOMMENDATIONS

In order to develop the groundwater in wadi Esel the following are recommended:

1 - Full utilization of the fresh groundwater of the fractured Hammamat

aquifer by drilling at least two productive wells at selected sites around the hand dug wells 5 and 6.

2 - Quantitative evaluation of the Middle Miocene sandstone aquifer by drilling new wells and use its groundwater for agricultural activities.

3 - Carry out drilling operations in the delta of wadi Esel to explore and evaluate the alluvial aquifer.

REFERENCES

El-Akkad, S. and Dardir. A. A. (1966) : "Geology and phosphate deposits of Wasif-safaga area". Geol. Survey, Egypt, paper No. 36.

El-Fakharany, M. A. (1989) : "Hydrogeology of Quseir area and its vicinities". M.Sc. Thesis, Fac. of Sci., Cairo Univ., Egypt.

Hem, J.D. (1959) : "Study and interpretation of the chemical characteristics of natural water". Geol. Survey, Water Supply, U.S.A.

Issawi, B., *et al.* (1971) : "Geology of safaga-Quseir coastal plain and the Mohamed Rabah area". Annals, Geol. Survey, Egypt, Vol. 1.

Sabit, A. H. and Bykov, B. A. (1976) : "Geological map, Quseir sheet, Eastern Desert, Egypt". Geol. Survey, internal report.

Schoeller, H. (1962) : "Geochemie des eaux souteraines". Rev. de 1' Institute francais du petrole, Vol. 10.

Sewidan. A. S. (1990) : "Evaluation of formation constants for some localities in the Eastern Desert, Egypt". Geol. Survey, Egypt (in press).

U.S. Public Health Service(1982) : "Drinking water standards". U.S. Public Health Service, publ. 959.

U.S. Salinity Laboratory Staff (1954) : "Diagnosis and improvement of saline and alkaline soils". U.S. Dept. Agric., Handbook No. 60.

المياة الجوفية فى حوض وادى أسل الصحراء الشرقية - مصر

مصطفى محمد الغزاوى وعبد المتعال عبد الباقى

مركز بحوث الصحراء - القاهرة

يهدف هذا البحث الى دراسة المياة الجوفية بحوض وادى اسل الذى يقع على بعد حوالى ٢٠كم الى الجنوب من مدينة القصير - وترجع أهمية هذا الحوض الى تزايد الاهتمام بالمياة الجوفية فى الصحراء الشرقية ككل لاستخدامها فى خدمة مناطق التعدين المنتشرة بها ومنها منطقة القصير التى تعتبر من أهم مناطق الفوسفات فى مصر وكذلك لاستخدام سكان المنطقة الاصليين.

قسمت التكوينات الحاملة للمياة بحوض وادى اسل الى ثلاث تكوينات هى الحديث والميوسين الاوسط وصخور الحمامات المتشققة التابعة لعصور ما قبل الكمبرى - وقد ناقش البحث ظروف تواجد المياة الجوفية بكل تكوين على حدة وصفاتها الطبيعية وتوزيعها الجغرافى ودور التراكيب الجيولوجية خاصة الصدوع والشقوق على ظروف التغذية بها.

اما من الناحية الهيدروكيميائية فقد ناقش البحث الخصائص الكيميائية للمياة بكل تكون من حيث الملوحة وسيادة الايونات والاملاح الافتراضية . كما تم تمثيل التركيب الكيميائى للمياة على تقسيم شولار الذى أوضح أن هناك تشابة بين نوعيات المياة من خلال تركيزات العناصر الاساسية بها وكذلك أوضح التشابة الواضح بينها وبين مياة الامطار حيث امكن اعزاء اصل المياة بتكوينات الميوسين والحمامات الي مياة الامطار.

وقد تضمن البحث ايضا مناقشة صلاحية المياة للاستخدام المنزلى وكذلك استخدامها فى اغراً ض الرى (بتطبيق بعض الطرق) . وتوصلت النتائج الى امكانية استعمال بعضها فى الاغراض المذكورة.

واخيرا وضعت توصيات بحفر المزيد من الآبار للدراسة والاستغلال.